Climate change impacts on the Italian wine sector: challenges and prospects for Sangiovese production in the Romagna area

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Climate change is arguably the most severe challenge facing our planet during the 21st century and it is a phenomenon widely recognize by the scientific community. The major causes for the climate change depend directly from the human activity, such as burning fossil fuels, deforestation, livestock, nitrogen fertilizers, fluorinated greenhouse gases (IPCC, 2014).

Due to the evidence and to the impact caused by climate change, the international community have focused its attention on defining measures to mitigate climate change and to adapt the social and economic system to its effects, through the implementation of several targeted policies. In fact climate change has a transboundary nature and a global scope, and it can only be addressed effectively through international co-operation. The principal agreements that have been signed for climate change mitigation and adaptation are the Vienna Convention for the Protection of the Ozone Layer (1985), the Montreal Protocol (1987), the UNFCCC Framework Convention on Climate Change (1992) and the Kyoto Protocol (1997). At supranational level, in the last 10 years, European Union focused its attention mainly on the adaptation options in the main strategic document represented by the Green and White paper, approved in 2007 and 2009. The EU strategy includes the Guidelines on developing adaptation strategies at national levels. However not all the member states develop its own strategy yet. The Italian national government presented its own national strategy in 2014 and the Emilia-Romagna region is actually working on the Regional strategy.

Climate change affects several economic sectors and, in particular, agriculture. In fact the rising of global temperature, the decrease in the mean annual rainfall in the Mediterranean area, the fewer cold days and the increase of the number of days with high temperatures and the of the climate variability, have a huge impact in the agricultural system and also in the viticulture production (Fischer et al., 2005; EEA, 2015; Hannah et al., 2013; van Leeuwen et al., 2004; Urhausen et al. 2011).

The tight connection between climate change and wine production is today widely recognized (Stock et al., 2005). In fact, wine grape yield and quality are largely dependent on climatic conditions, particularly during the growing season (Jones & Davis, 2000; van Leeuwen et al., 2004; Urhausen et al., 2011) and
weather fluctuations are likely to occur along the thirty years of a vineyard life cycle. Further, in the last decades, global warming and extreme atmospheric events intensified significantly. The main effects of climate change on wine production entail increasing plant diseases, variations in alcoholic and sugar content, leaching out and soil erosion (Anderson et al., 2008; Ashenfelter and Storchmann, 2014; Sadras et al., 2012), that in turn have huge repercussions on prices, rents and profits. In cases of extreme extent, the typical wine-growing regions (between 20 and 53° latitudes in the northern hemisphere and 20 and 42° in the southern hemisphere) may also become unsuitable terroir. This is why, an increasing number of contributes in the scientific literature focus on the most appropriate adaptation practices and strategies, such as nighttime harvesting, berry spoilage (quicker delivery of the berries to the winery), Integrated Pest Management, the use of more alcohol-tolerant yeast strains, etc. (Keller, 2010; Butt & Copping, 2000; Vink et al., 2009; Schultz, 2000). Further, the economic literature has begun to examine this issue with the goal to recommend appropriate investment and portfolio strategies (Adams et al., 1998).

Given these premises, this research investigates the adaptation capacity to climate change of the agri-food farms, with particular reference to the vine growing and wine making farms of Emilia-Romagna that produce Sangiovese, where adaptive capacity means the ability of a system to recover or adapt (cooping or resilient) to changing external conditions, reducing its negative impacts, and anticipating change for the future by adopting long-term strategies.

Furthermore, the research aimed at developing a method for assessing adaptation capacity sufficiently specific to capture local variation but which can also be transferred to other sites and crops later.

Material and methods

In light of the background research and the literature review conducted, to achieve the general and specific objectives, the logical framework has been build on an holistic approach that allows to combine different information from different sources. The research has been set up into three main economic theories:

- the Natural Resource-Based View (NRBV) theoretical approach (Hart, 1995) that traces the link between environmental actions and profit and it establishes a direct connection between the firms capabilities to gain competitive advantages while coping with the challenge of irreversible environmental change

- the behavioural economics (Artikov et al., 2006; Hu, 2006) and life cycle thinking theory (Falcone et al., 2015). can be well used to explain the
intentions for adopting specific adaptation practices and strategies and climate-friendly behavior in the context of climate change

- the geographical proximity theory (Marshall, 1980; Porter, 2000), according to which farms that interact within a territory at a meso-economic level, allowing cost reduction, knowledge exchange and the level of innovation of individual businesses.

The analysis of those economic theories applied to the context of climate change, allows to identify the main factors that can influence the adaptation capacity and leads to the definition of 5 research questions concerning:

Q1: Is the number of adaptation practices related to the impacts of climate change?

Q2: Is the structural characteristics of the farms related to the implementation of adaptation practices?

Q3: Is the producer perception of climate change related to the implementation of adaptation practices?

Q4: Is the local climatic variability related to the implementation of adaptation strategies?

Q5: Is the environmental and farms process certification related to the impact of climate change, at agronomic and economic level?

The assessment of adaptation capacity on wine farms is based on the empirical evidence gathered in the Romagna region, an important traditional wine producing territory in Italy, with particular reference to the production of Sangiovese, a very sensitive grape variety to climate change effect.

The data collection has been composed by a mix of data from secondary and primary sources.

The secondary data are represented by the climatic data collected at regional and at the vineyard levels, collected through the regional climate records and database of AGREA. The analysis of regional climatic data leads to the definition of the three years most affected by different effects of climate change in the last 15 years. The identification of those years allowed to define the adaptation practices and assess the impact in the different years into the primary data source. Instead, the analysis of climate data at vineyard level allowed to classify the wine farms involved in the research by the temperature and precipitation variability.

The primary data coming from a direct survey submitting a questionnaire on 200 wine farms, selected in collaboration with local Consortia and Certification bodies. The questionnaire, based on three years identified above, assessed the
influence of various groups of factors on the adaptation capacity of wine farms to climate change: such as farm structure and features, producer perception of climate change, technical and economic aspects (including costs and investments) and both short-run and long-run adaptation practices and strategies.

Data collected from 56 wine firms and from climatic data at vineyard level have been classified and elaborated by means of multivariate statistical technique (cluster analysis) to categorize respondents and variables into groups based on the factor that influence the adaptation capacity to bear the economic management of climate change.

Then the Bayesian network (BN) has been applied. Bayesian network is a probabilistic graphical model, in order to facilitate learning about causal relationships between variables, combining quantitative and qualitative data and integrating social, ecological and economic factors (Bromley et al., 2005) to assess the process of adaptive management (Smith et al., 2007).

Results and discussion

The climatic data has been analyzed at two level, regional and at vineyard level. At regional level the analysis leads to the identification of the years that have been mostly affected by climate change effect in the last 15 years and the year 2003 has been identified as very hot, 2012 very dry and 2014 very rainy.

Results show that farmers perceive the ongoing change in climate conditions and identify temperature and rainfall as the environmental factors that mainly affect wine production with a larger impact in the vineyard than the cellar. Furthermore, the majority of the produces declare that the climate change has a high incidence on the choice of practices to implement.

As far as adaptation practices concerned, in the short-run, farmers react by adjusting agronomic practices (i.e. changes in the date of collection, soil and water management) and balancing technical and economic issues. In particular the year that requires more adaptation practices is the rainy one, imposing a change in harvest dates as well as cultivation practices, mainly concern the use of plant protection treatments.

In the long-run, in order to maintain a sustainable competitive advantage, changes in the practices that wine-growers adopt to overcome the new climatic challenges entail the adoption of management and adaptation strategies (, new rootstock, new varieties, modification of plant density, irrigation system, mechanized harvesting, investment etc.), as well as appropriate policies in terms of regulation, incentives and support.

The consequences of climate change have been calculated as percent deviation from standard year.
Results show that yield decrease in the three years, with a lower reduction in the rainy season, when also a drop in alcohol content is registered. Costs, unlike in dry year, are rising, more substantial in rainy year, coupled with more phytosanitary practices and treatments.

The cluster analysis technique subdivided the sample in relation to the characteristics of farms, climate change perception and environmental attitude (some of the factors that influence the adaptation capacity). The results are show in the table 1.

Table 1: Clusters characterizing the factor that influence the adaptation capacity of wine growing farms to cope with climate change

<table>
<thead>
<tr>
<th>Factor that influence the adaptation capacity</th>
<th>Clustering variables</th>
<th>Cluster Obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C.1 Farm characteristics</strong></td>
<td>Organizational form</td>
<td>C.1.1 Small farms with a single vineyard and no mechanized harvest</td>
</tr>
<tr>
<td></td>
<td>Annual employees</td>
<td>C.1.2 Medium sized farms, with annual employees and national and international destination markets</td>
</tr>
<tr>
<td></td>
<td>Mechanized harvesting</td>
<td>C.1.3 Large farms with parcelled vineyards and mechanized harvesting</td>
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<tr>
<td></td>
<td>Planted area</td>
<td></td>
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<td></td>
<td>Market</td>
<td></td>
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<tr>
<td></td>
<td>Vineyard fragmentation</td>
<td></td>
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<tr>
<td><strong>C.2 Climate change perception</strong></td>
<td>Forecasting models</td>
<td>C.2.1 Producers with low perception of climate change</td>
</tr>
<tr>
<td></td>
<td>Grape sensitivity</td>
<td>C.2.2 Producers with high perception of climate change</td>
</tr>
<tr>
<td></td>
<td>Environmental factor</td>
<td></td>
</tr>
<tr>
<td><strong>C.3 Environmental attitude</strong></td>
<td>Sustainability practices</td>
<td>C.3.1 Low environmental attitude</td>
</tr>
<tr>
<td></td>
<td>Environmental label (ISO, Organic etc.)</td>
<td>C.3.2 High environmental attitude</td>
</tr>
</tbody>
</table>

The three clusters obtained were useful for the Bayesian network design and implementation. The structure of the network include, on the left side there, the factor influencing the adaptation capacity (environmental attitude, characteristics of the farms, climate change perception and climate variability represented by the Winkler index and water surplus), in the middle, the adaptation practices carry on in the different years (hot, dry and rainy) and, on the right side, the impacts of climate change in the same years on yield, alcohol content and costs, as well as the long term strategies.

The general overview of the network show that, with the highest probability, the farm is medium size and the producers have high environmental attitude, high perception of the issue if climate change and a clearly long-term vision. They implement between few adaptation practices (between 1 and 3) in sensitive years, with a mayor rate in the rainy years, when the maximum increase of costs is also registered. The alcohol content register the mayor value during the hot year while the lowest impact of climate change is registered in the dry year.
Analyzing the variables that compose the research questions, the results show that there is no clear relationship between the number of adaptation practices and the magnitude of the impacts, which suggests that, probably, the impacts are more related to the availability of tools such as access to water. In the rainy years the highest number of adaptation practices is related to the cost increase (87%) (phytosanitary treatment).

Moreover, the model shows that the large companies are more likely to implement more adaptation practices in particular in dry and rainy years. This aspect may be related to the greater organizational, managerial and financial capacity that differentiates them from smaller companies. However, it is interesting to note that small companies register a 34% probability of implementing a large number of adaptation practices in hot years. This could be explained by the need to compensate for the lack of an irrigation system with cultivation practices, soil management and variation on harvest dates.

With regard to long-term prospects, all companies provide with high probability to adopt adaptation strategies to safeguard production and to ensure good business performance in the future.

Regarding the producer perception of climate change, the model show that perception is a factor that may not significantly affect the number of adaptation practices that wine growers implement. However, there is an evident difference for the long-term strategies: producers with a clear perception should, with a probability equal to 83% of having to deal with the effects of climate change by implementing long term strategies; the producer with a lower perception record a long-term vision with a probability of only 48%.

Climate variability, computed over the last 15 years, has not shown any correlation with the adaptation practices that producers implement in difficult years from the climatic point of view. This demonstrates that wine growers react to climate issues by adapting their day-to-day production techniques in reactive form. Instead, the relationship between the climatic variability recorded in recent years and the long-term adaptation for the future is clear. In particular this relationship is evident for the Winkler index and water surplus show that in high variability, the probability that the producer has to implement long-term strategies is highest than in low climatic variability conditions.

The model results also show how environmental attitude of companies does not have a clear relationship to the impacts of climate change. This can be explained by the fact that environmental attitude of companies (in particular if they have environmental and process certification) aggregates value to the final product, in terms of image of the product and the company while it is not related to the technical, managerial and financial capacity of a company to cope with climate change impacts in vineyards and cellars.
Only if environmental concerns translate into strategic actions such as the development of a new product, the location of new production facilities, increased investment in research and technological development, and changes in product and process design, these can provide greater adaptation capability to climate change.

CONCLUSIONS

The management and adaptation strategies can largely reduce the potential impacts of climate change and climate variability on wine production and farmer income. However, the adaptation capacity of wine-making enterprises is related to producer behavior (adaptation practices and strategies and readiness to change) and it is largely dependent on structural and technical farm characteristics, producer perception of climate change and climate variability. In particular, the climate variability influences more the long term vision of the producers than the day-by-day adaptation. For this reason it will be necessary improve the accuracy in predictions of climate phenomena at the micro level.

In any case, the producers are aware of the efforts which are required to cope climate change in the future, in fact they perceive the necessity to implement adaptation strategies such as new rootstock, new varieties, specific investments, in particular for the irrigation system and mechanized harvesting.

Thus, in order to support the wine farms and to safeguard the wine production in the future, it is necessary to improve the level of knowledge, information and research about the innovative management systems and adaptation options. Furthermore, the introduction of tools and form of assistance for the adoption of adaptation and mitigation measures in the local supporting policies is crucial.

Finally, the survey shows how the producers interviewed declare to rely on, for the choice of practices and strategies to be implemented, mainly on personal knowledge and / or on confrontation with colleagues. This aspect confirms the theory of proximity or geographical proximity, according to which geographic enterprises, such as regional clusters that are in specific climatic conditions and soil composition, worker sharing, in terms of human capital, and specialized suppliers, developing common strategies for the sector (Romanelli & Khessina, 2005; Saxenian & Saxenian, 1994; Spender, 1989)
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